Research on the Progress of VR in Game

Ruiqi Zhang *

School of Computer Science, University of Nottingham Ningbo China, 199 Taikang East Road Ningbo, 315100, China

* Corresponding author Email: scyrz5@nottingham.edu.cn

Abstract. Virtual reality technology has evolved from the last century to the present, with huge improvements in performance, graphics quality and portability of headset devices. Major game manufacturers and studios have launched virtual reality games that use virtual reality technology. Compared with traditional games, virtual reality games have a strong sense of immersion, presence and interactivity, and are very popular among players. This paper summarizes the development history of VR devices and VR games, outlines the importance of VR in game design and development - the strong immersion and interactivity of VR games compared with traditional games, and explains the applications of VR in various types of games, among which are scenario-experiencing games with exploration games and social games, action-simulation games with sports and role-playing games, and educational games for teaching purposes, and points out that there are still shortcomings in the development and design of current virtual reality games, and developers of virtual reality devices and games need to work together to make virtual reality games have more application scenarios and meanings. The hotspots and development prospects of VR games at the current stage are prospected.

Keywords: Virtual Reality; Game Design; VR Game; Game Develop.

1. Introduction

With the rapid popularity of electronic devices and market expansion of international game companies, video games are gradually becoming an important part of modern leisure and entertainment activities. According to Newzoo's report, the global game market harvested $175.8 billion in revenue in 2021, and this figure is expected to grow to $218.7 billion by 2024 [1].

The video game industry shows the trend of rapid growth of market scale and diversification and diversification of development direction. Players and developers are no longer limited to the game through the traditional PC and smart phones, part of the players use VR devices to play video games. Virtual reality technology has gradually come into the public's view in recent years, which provides deep visual immersion and natural and smooth interactive experience. Users are able to experience a strong sense of presence and realistic movements, and break through geographical limitations to zero in on the virtual world. These features make VR games an important application in VR technology, and as game makers invest more in the VR industry, VR games have increased the content richness of the game market. According to the famous video game digital distribution platform Steam, the number of users of VR headsets on Steam reached 3.4 million in January 2021, which is on an upward trend [2].

According to a study by Shelstad et al, after participants used the Oculus Rift VR headset once and a traditional monitor another time to play a game called Defense Grid 2, players rated the sound and graphics experience of the VR version of the game higher, which would lead to higher satisfaction and immersion than playing the traditional version of the game. In another experiment, Peng et al. found that players using VR devices to play games generated more pleasure and more positive emotions than when playing traditional games [3]. There is enough evidence to show that the application of VR technology in the field of game design and development has a wide scope for development. However, at the current stage there are not too many researchers comprehensively studying the application of VR in game development and design. This paper will review the development history of virtual reality technology, study the importance of VR in the field of video

games and its application in various games, and analyze the shortcomings of the current VR game development and design field.

2. The Development History of VR Devices and VR Games

The concept of VR first came from Stanley G. Weinbaum's science fiction novel "Pygmalion's Spectacles," which detailed a virtual reality system based on smell, touch and panoramic image goggles, but the state of technology at the time made it impossible to achieve this effect in the real world (Fig.1). In 1962, a relatively early virtual reality device used for entertainment "Sensorama" was manufactured by Morton Heilig, this device can provide users with a variety of sensory special experience, was used to create a "theater of experience" for the audience. In 1968, Ivan Edward Sutherland and his student Bob Sproull built the first VR device, "The Sword of Damocles", but it remained in the lab because of its very bulky design and lower safety margin (Fig.2) [4].

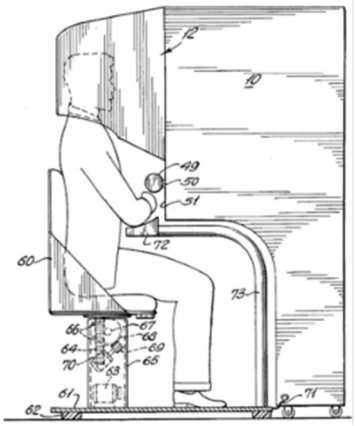

Fig 1. Sensorama

Fig 2. The Sword of Damocles

Between 1990 and 2000, SEGA and Nintendo launched their own VR devices: the SEGA VR-1 and Virtual Boy, which were able to initially track the user's head movements and react to them. During this period, such as Descent, StarWars: Dark Forces and other physical games were born. But SEGA announced the termination of research and development due to the technical problems of headaches and motion sickness caused by users using VR devices. Nintendo also due to the slow development progress, the launch of the product is not completed and lead to dismal sales. To this point, the market for VR games in the 19th century is not very optimistic. However, during this period the major well-known game manufacturers saw the good prospects of VR technology in the field of gaming, have begun to overcome the technical difficulties of VR devices [5].

2011, Nintendo launched a portable game console 3DS that provides naked eye 3D capabilities, with a strong sense of realism and immersion in the visual aspect. 2012, Oculus Rift, a device with two goggles, binocular resolution higher in 2014, Facebook acquired Oculus for $2 billion, and at the same time, SONY also released the PS VR, the two technology giants entered the VR market announcing the beginning of the first year of VR.

Between 2016 and 2020, technology companies including Sony, Samsung and Google have launched various types of VR devices, such as game consoles/PCs, mobile and standalone all-in-one devices. PC-based VR headset sets are the highest-end device type, with screen rendering done by host-class graphics cards, featuring fine screen output and smooth visual experience, and are the best choice for acquiring the best choice for high-quality VR game content, however, because it must rely on a wired connection with a PC or game console, there are high restrictions on the player's range of motion [6]. The representative products are HTC Vive, Valve Index and Sony PSVR, etc. Mobile VR devices refer to devices that rely on smartphones to complete computing and output, such devices require players to build smartphones into their head display devices, using the optical nature of the phone screen itself for screen output, high portability, but due to the weak cell phone chip arithmetic,

making it difficult for players to get a smooth and clear gaming experience, and eventually, Google DayDream, etc. announced the discontinuation of such mobile kit devices mainly to video, streaming and other VR fields that do not require high performance. Stand-alone all-in-one VR devices are the new trend in VR equipment products and are the type of equipment that major manufacturers are currently focusing on developing. This device does not need to be connected to a computer or smartphone, through the built-in all-in-one display, processor, memory, battery and other hardware for computing and screen output, although the performance is not as good as the host end of the device, but because of its high mobility and integration, by the user's welcome. Oculus Quest, HTC Vivi and other products have a high sale (Fig.3). Among them, the second generation of VR equipment Oculus Quest2, which was released by Facebook in 2020, the configuration of the new upgrade brings a significant improvement in the VR experience, leading to a surge in sales, is expected to become the first consumer-level single product in the history of VR equipment sales of more than 10 million.

Fig 3. HTC Vive

3. The Importance of VR in Game Design and Development

Along with the development of online game technology, players' experiential demand for games is gradually increasing, and they are more inclined to be in the entertainment experience brought by the real game environment. Virtual reality games have strong interactivity and immersive game environment, which can effectively enrich the form of entertainment for players. Virtual reality technology makes players and game characters become one, leading players to cross the border between reality and reality.

3.1 Immersion of VR Games

Flow theory was proposed by Csikszentmihalyi in 1975 in his book Beyond Boredom and Anxiety. The human senses of sight, hearing, touch, smell and taste are called sensory systems, and these sensory systems allow people to feel different experiences through the corresponding neurotransmitter stimuli. However, the role of VR is to send virtual things to the human brain through the same sensory system output, the player gets similar feelings and emotional activities with the real world, so that the player sees himself as part of the virtual world [7]. According to Pimentel and Teixeira, the shift in thinking required for players to switch from the real world to the virtual reality world is the same as the shift in thinking required for players to immerse themselves in a traditional game while playing it. Research by Pallavicini et al. has shown that players playing games in a VR world will experience a greater sense of presence and immersion than playing regular games. The degree to which players feel this virtual world is known as immersion, and the level of immersion is naturally one of the main factors in assessing how good VR is.

In fact, no matter what type of game, a beautifully designed game will give players an immersive experience. In traditional games, the human sensory system interacts directly with real objects, but in VR games, the environment perceived by the player is a completely virtual simulation, and the

player's subject will and sense of time and space are stripped away to the virtual world, making the immersive experience players get in VR games far more than the experience they get when playing traditional games using peripherals such as keyboard and mouse, monitors, etc. When the player wears VR equipment, there is almost no physical separation between the person and the game screen. The immersion in VR games is highlighted by the fact that the world in VR games does not rely on images alone to convey to the player. the world of VR games is a multi-dimensional world that goes beyond the visual single dimension, expanding and filling the player's senses with the game's scenery so that the player clearly feels he is in the scene of the game. In the visual part, Head Mounted Display (HMD) is placed in front of the player's eyes, the game rendered out of the picture simulated by the player's eyes to see and block the external real world on the player's visual impact. In the auditory part, VR equipment through stereo speakers output sound to the player's ears, constituting the sound of the virtual space [5]. The haptic part is done by the player wearing haptic feedback gloves or holding the haptic feedback handle. Since the experience of smell and taste are mostly chemical substances, which cannot be simulated by computer, they are less simulated in VR and VR games. Dance Central, a dancing game created specifically for VR, is a good example (Fig.4). This game set players in a ballroom can be invited through the hands of the phone virtual NPC friends to choose a song to dance together. In the process of dancing, NPC dance partners will follow different music to make some different dance posture, and the player is asked to make the same action. The faster and more accurate the player's moves are, the higher the score will be. Dance Central integrates music, special effects and movement into an all-around sensory feast that gives players a strong sense of immersion. VR controls the player's attention, creating a pleasant and relaxing game experience that mobilizes a higher level of sensory involvement.

Fig 4. Green flames shown when players dance with NPC in Dance Central

3.2 Interactivity of VR Games

For VR games, high-quality and interesting interaction is one of the key factors that determine the experience. interactivity in VR games refers to player-interface interaction and player-player interaction. Before the advent of VR, players interacted with the game interface by clicking on windows, menus, icons, and other two-dimensional graphics displayed on the monitor. VR transforms the way the player interacts with the game into a virtual 3D game world, so that the player can interact intelligently with all the elements of the game world using physical movements and real sensory systems. This interaction technology allows the player and the game to be perfectly integrated to form a smooth and realistic interaction experience.

Currently, VR games use the controller provided by the headset to control the player's movements. Unlike traditional games mouse and keyboard or handle to operate, the controller of VR equipment integrated with complex sensors, the player's movements will be received by a variety of corresponding sensors, which are calculated by the computing unit output into real-time, the same as the player's real body movements, mapped to the virtual game world. In addition to sensors, VR controllers also retain the traditional physical buttons and joysticks and other control units, players and developers can customize their settings as they wish [8].

Research shows that when players play games, if the characters in the game are perceived by players to act realistically, players will unconsciously create an illusion of bodily ownership, and this illusion will make players feel more present in the game and more likely to feel that the characters in the game are interacting with them in a realistic way. For example, in the popular VR game Half-Life: Alyx, players use a virtual hand to interact with objects and characters in the game instead of gestures, just like in real life. Players can control the protagonist's hand to pick up the pen to draw on the glass, you can crack the glass bottle, or pull the bolt, change the magazine to use the gun. For players, compared to all operations can only be completed by pressing the keyboard, this interaction is far stronger than in traditional games to control the character, VR games operate more to make players feel a sense of reality.

4. Application of VR in Game Design and Development

4.1 The Application of VR in Scenario Experience-based Games

Scene experience-based games include exploration games, social games, etc. In exploration games, VR creates a virtual space complemented by a plot setting that places the player in a specific scenario and time period. For example, the Quest store shelves the exploration game National Geographic Explore VR, in which the player takes on the role of a National Geographic photographer, traveling around the world and taking photos for the magazine. Players can use the camera in their hands to capture the surrounding scenery. One of the scenes is the Antarctic glaciers, the player will be in a small kayak, real paddle to move, the surrounding seawater, glaciers will be rendered in real time. Players can also climb snowy mountains with climbing picks, and will experience bad weather such as snowstorms. The sensory stimulation conveyed to players by such VR exploration games is unmatched by traditional ordinary games. Another type of VR game is the social category. The social category gives players the opportunity to meet and interact with others in the virtual world. Players choose or create an avatar and support the conveyance of full-body movements, expressing themselves through actions and gestures.

4.2 The Application of VR in Action Simulation Games

Action simulation games include sports, RPG (Role Play Game) category, etc. In action games, players play the role of the game in the first-person perspective, using real behavior (such as swinging, kicking, running, raising guns, etc.) to control the role of the game to complete the corresponding action, so that players are more immersive into the game world. Compared to other game genres, VR action games focus more on the sense of immersion brought to players by the operation experience, allowing players to control their own bodies as comfortable as operating the role in the game, so as to truly experience the sense of combat in the game. Action games cover fighting, shooting, multiplayer battles and so on. FPS (Fist Person Shooter) games are the most popular type of VR games, FPS games with a new sense of operation and three-dimensional audio-visual with the user immersed in a tense combat atmosphere. The military simulation FPS game "Onward" developed by American game studio Downpour Interactive and published by British game maker Coatsink (Fig.5).

Fig 5. Onward

For example, adopts a first-person perspective and supports 10 players in the same battlefield, realistically simulating the battlefield environment. Players can walk, dodge, maneuver, reach for guns, load magazines, reach over their shoulders, talk to their teammates on the radio, or grab a grenade on their belt, pull out the safety pin of the grenade and throw it at the enemy in a realistic physical environment. When the enemy fires at the player, the player may unconsciously hide, and this realistic experience can be extremely exciting and exhilarating [9]. Sports games, which are controlled by the player's body movement, players can experience the fun of a variety of sports without leaving home, increasing the motivation of players to exercise. With the launch of Microsoft Kinect and Sony Eye Toy, exercise games through physical control were once very popular. VR emerged, immersive interaction and music with the overall experience of such games has greatly improved. The VR sports games are mostly ball games, racing games, rhythm games, etc. There are different ways to interact with each other to meet the simulation of various body movements. Among them, racing games first use VR, whether the first-person view of the screen or simulation of the steering wheel, racing games need to have all the conditions are almost tailor-made for VR games, intense racing brought by the sense of excitement is unmatched by other sports games. Then ball and rhythm games have been launched in VR versions.

Beat Saber has become one of the best-selling games in VR, with intuitive and lively interaction, sophisticated kinetic scenes and high-definition graphics. Players need to select songs from a library of thousands of tracks, use VR motion controllers to swing a pair of blue and red lightsabers, cut through oncoming squares of the corresponding color to dynamic music, and crouch or move left and right to avoid walls. This new type of sports game has a high popularity for casual players, it does not require complex interface conversion, players also only need to carry out regular, repetitive movements, reducing the chances of player motion sickness, streamlined operation also reduces the difficulty of getting started. Instantly no VR operation experience players can also quickly learn and play. The game has achieved remarkable results in the VR market and is widely recognized by the player community, selling more than one million copies and generating more than $20 million in revenue nine months after its release in 2018. Judging from Beat Saber's success story, such VR sports games can be a way for players to exercise, become a part of their lives, and even have a positive effect on their health (Fig.6).

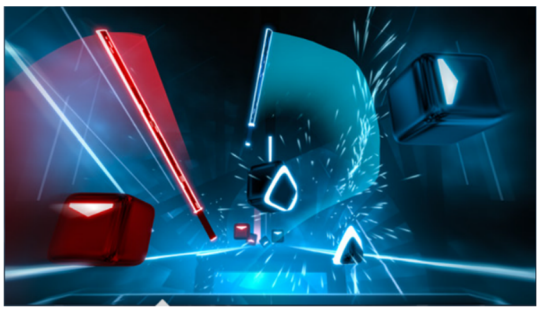

Fig 6. Beat Saber

RPG games, with the high immersion brought by VR technology, provide a better plot experience, game developers can better tell the story to the player, the player has a better sense of experience in everything they do in the game world, more can be integrated into the game world, play the role played in the game is crucial.

4.3 The Application of VR in Educational Games

From the most primitive oral education to the modern diversified education with multimedia participation, the educational approach has been adapting and accepting the new technological media brought by the development of technology. Situated learning theory suggests that meaningful structures can only be constructed if the learning process incorporates authentic contexts. VR technology is characterized by its ability to make it easier for the educator to integrate with the

situation to be learned, and its gamified simulations are of great benefit to knowledge acquisition and retention. VR has the ability to provide standardized scenarios at a relatively low cost, allowing complex operations and information to be fluidly visualized and experienced by the educator and remembered and understood.

Oblinger et al. suggest that virtual reality technology has the property of learning transfer in education and training, which means that learners can better apply the learned skills in real situations by learning in virtual reality environments.

VR educational games use VR technology as a basis to allow educated people to learn in a happy and realistic context, transforming tedious learning content into a highly interactive experience, making learning both educational and playful, and allowing educated people to achieve simultaneous physical and mental cognition, thus improving learning efficiency. According to Dinis et al, in civil engineering education, virtual reality technology can enable students without prior preparation or with a low knowledge base to better understand the relevant knowledge.

VR games also have more applications in the field of language applications and education. For example, the language education VR game Mondly: Learn Languages in VR, in this game, players can choose English, Japanese, Chinese and other 29 languages to practice, players can talk with virtual characters in restaurants, trains and other environments, the game can recognize what players say by voice, players can get timely feedback about pronunciation, rich The game can recognize what the player says by voice, and the player can get timely feedback about pronunciation, vocabulary enrichment suggestions, so that the player can experience the most advanced way of language learning even at home. A similar game is MageVR, in which players learn with virtual partners of various personalities and images, and receive a complete feedback and progression system to reinforce the learning effect [10].

Educational VR games also have a high degree of application in the medical field. High School Anatomy for Quest is a VR educational game that includes up to 10,000 accurate anatomical models common to medical students and doctors, with each part of the model interactive and viewable. The detailed graphics and intuitive controls allow players to explore the human body from another perspective, providing an efficient learning style and an immersive learning environment.

There are clear examples that VR educational games are a reflection of the interactive nature of VR games. Learning in a VR environment makes learners more interested, and VR games can help students understand complex concepts visually and reduce misunderstandings. Educational games can increase learner engagement and motivation, making learners participants in the learning process rather than passive recipients of knowledge.

4.4 The Current Drawbacks of VR Games

- **Equipment limitations.**
  Today's VR games usually need to wear thick VR headset equipment, if it is a wireless device to go out, players also need to carry the equipment bag, and in the outdoors when they wear glasses is also unsafe.
- **Physiological adaptation restrictions.**
  VR games have a hard requirement that special headset equipment must be worn to play, if the player wears this equipment will produce motion sickness and other discomfort, then the player cannot play such games.
- **Equipment performance restrictions.**
  The screen clarity and latency problems of VR devices are still unresolved, but these technical problems will be solved slowly over time.
- **Space restrictions.**
  Generally, VR games require a lot of indoor space, many players are temporarily without this condition.

5. Conclusion

Since the 1950s, virtual reality technology has been introduced from vague concepts to concrete products and used in the gaming field. Updates in VR devices and VR technology have complemented the development of VR games. VR games have two advantages compared to traditional games: strong game immersion and real-time human-machine interaction. Scene experience and action simulation games played through VR equipment can greatly enhance the experience of the game, and VR games can also be used in the education industry to enrich the form of teaching and improve the teaching effect. However, there are still some shortcomings in VR games, the ecology of VR games still needs to be enriched, and the cost and price of VR equipment still needs to be reduced. The purpose of this paper is to analyze the trends and characteristics of VR game development at the current stage, and hope more researchers will devote themselves to studying this field. The evolution of VR games shows that developers will continue to make their worlds more immersive, interactive and fun.

References

[1] Shelstad, W. J., Smith, D. C., & Chaparro, B. S. Gaming on the Rift: How Virtual Reality Affects Game User Satisfaction. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 2017, 61(1), 2072-2076.

[2] Harris, Weems, Henderson. Through the Looking Glass: Copyright Protection in the Virtual Reality of Second Life. Journal of Intellectual Property Law, 2016, 7(1):1-10.

[3] Pimentel, K., & Teixeira, K. Virtual reality: Through the new looking glass. New York: Intel/McGraw-Hill 1995, 47:478-484.

[4] Sanchez-Vives, M.V, Spanlang, B., Frisoli, A., et al. Virtual Hand Illusion Induced by Visuomotor Corelations. PLoSOne.2020.5(4) p.10381.

[5] Peng, X., Huang, J., Li, L., Beyond horror and fear: Exploring player experience invoked by emotional challenge in VR games. In Proceedings of the 2019 CHI conference on human factors in computing systems. 2019,9(3): 1–6.

[6] Hanifah H, Ito Y, Yao D, et al. Promoting Sports Engagement during the COVID-19 Pandemic via Virtual Reality Games. Occupational Therapy International, 2022, 2022(6):1-10.

[7] Pallavicini, F., & Pepe, A. Comparing player experience in video games played in virtual reality or on desktop displays: Immersion, flow, and positive emotions. In Proceedings of Chi Play, 2019 4(1):195–210.

[8] Aline Menin, Rafael Torchelsen, Luciana Nedel. An analysis of VR technology used in immersive simulations with a serious game perspective. IEEE Computer Graphics and Applications, Institute of Electrical and Electronics Engineers, 2018, 03:404-408.

[9] F. M. Dinis, A. S. Guimarães, B. R. Carvalho and J. P. Poças Martins, Development of virtual reality game-based interfaces for civil engineering education, 2017 IEEE Global Engineering Education Conference, 2017 2(19):1195-1202.

[10] Oblinger Diana. Simulations, Games, and Learning. Virtual Worlds,2006, (1):1-6.